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ON SHAFT FILLET STRESS CONCENTRATION

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Abstract. A shaft is typically loaded by three different load types; torsional, bending and normal load separately or more generally in combinations. In most cases the size of the shaft is controlled by the constraints on the maximum allowable deflection and/or rotation at e.g. the position of bearings or gears. But if care is not taken to limit the stress concentrations these will control the durability of the shaft. With the use of fillets we have stress concentration described by the stress concentration factor K_t (theoretic stress concentration factor).

The stress concentration factor is typically found in charts in textbooks or papers. The charts are given for circular fillets and for the three different loading situations separately. Many of the charts are based on experimental results from photo elasticity. The typical procedure for the case of a combination of the loading situation is to find the maximum stress resulting from each of the loadings and from these maximum values calculate a reference stress although the maximum stress is not found in the same point for the different load cases. With this procedure we end with a conservative estimate on the strength. Although structural optimization is a mature science and optimization have been performed on shafts this has had limited impact on the practical design of shafts, these are still mainly based on the circular fillet design.

The minimization of maximum stress and thereby increasing the strength of components can be found in many papers. The majority of papers deals with flat or circular bars in tension. Despite the large number of publication no optimization have been reported for the combined loading case to the knowledge of the author.

Typically relatively large improvements of the strength can be found for simple design modifications. Central for these design modifications is that revised design can still operate with the design specified by the standards. The evaluation of the stress concentration is performed using the FE method. For a successful application of shape optimization a couple of point are important. The main point is that the parameterization of the shape with the high stress is done separately from the FE meshing of the design domain, i.e. the position of the nodes in the FE mesh should not be used as design variables

Keywords: Machine elements, Optimization, Bending, Torsion, Normal force, Harmonic FE.